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Published in:
Human-Computer-Interaction - INTERACT 2021

Published: 01.01.2021

Document Version
Peer reviewed version

Citation for pulished version (APA):
Brun, D., Lehtinen, S., & Häkkilä, J. (2021). Discreet Interactive Wallpaper Concepts Study. In C. Ardito, R. Lanzilotti, A. Malizia, H. Petrie, A. Piccinno, G. Desolda, & K. Inkpen (Eds.), *Human-Computer-Interaction - INTERACT 2021: 18th IFIP TC 13 International Conference, Proceedings, Part V* (pp. 390-394). Springer. Lecture Notes in Computer Science

Discreet Interactive Wallpaper Concepts Study

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Abstract. In this paper, we address the design of discreet interactive wallpapers. We chart the initial user perceptions with a simulation-based user study (n = 14), where we evaluate different concepts specifically designed for electrochromic ink, ranging from ambient information delivery to gamification. Our research contributes background knowledge for designers and practitioners working with interactive environments.

Keywords: Interactive walls · Ambient displays · Electrochromic

1 Introduction

Smart and interactive environments are one of the main themes of ubiquitous computing, and research has addressed them from various viewpoints. For instance, the concept of interactive wallpapers has been explored to provide either useful, engaging or entertaining ambient experiences.

First, Huang and Waldvogel [4] defined the interactive wallpaper in four points: (1) operate in everyday life, (2) open, (3) spatial and (4) alive. The authors showed a series of implementations, mostly projector-based, blending decorative art and useful science. In the same vein, Campbell *et al.* [1] explored the concept of interactive wallpaper at home, providing scene-setting for immersive drama or additional content, such as recipes while watching a TV cooking show. Hoare *et al.* [3] explored an interactive hide-and-seek children-oriented game with wallpapers. However, despite showing benefits of using interactive wallpapers, previous works were mostly agnostic of the technical implementation and many years or decades later remain far-fetched to be integrated.

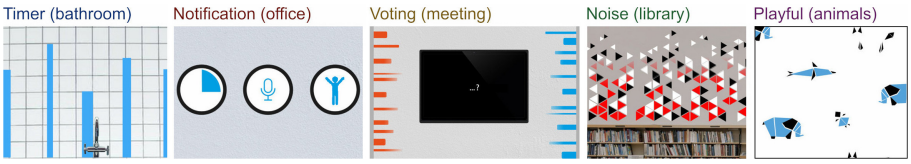

Fig. 1. Each abstract interactive wallpaper concept.

In this context, we address the topic of wallpapers with concepts based in the technical possibilities of interactive free-form graphics that can be manufactured with electrochromic inks, providing thin, transparent, flexible and low-power consuming displays. When an electric current is applied to the display, the ink moves from one place to the other, back and forth when reversing polarity. On the other hand, the displays have a limited number of colors and states and more importantly, do not emit light, thus, allowing visually discreet interactions, which are naturally integrated to indoor environments. The process of creating electrochromic displays is explained in detail by Jensen et al. [5].

We conducted a user study while specifically emulating the opportunities (low consumption, thus, blending solar panels into design) and limits (bi-state monochromatic graphical elements) of this technology as wallpapers. Each wallpaper concept (Fig. 1) aims to address different ideas:

- *Timer*, in our case taking place in the bathroom, with ink moving slowly decreasing one bar while increasing another. Multiple displays are stacked above each other, allowing a smooth transition.
- *Notification*, taking place in the office with the visual form of portholes. In this case, respectively (from left to right) alerting a future meeting, the microphone status and recall to move (or stand). When the notification is off, the ink is hidden around the border.
- *Voting* (more broadly the idea of communal expressing walls), with stacks of horizontal bars placed on opposite corners of a (meeting) room.
- *Noise* (ambient) with a colored repeated pattern showing its current level, in our case taking place in a library. The noisier the environment is, the higher (top) the displays are activated.
- *Playful*, taking the form of a hide-and-seek game with integrated solar panel elements (black shape) to a repeated pattern of animals. When an animal is hidden, the corresponding ink goes to a state placed behind the solar panel.

2 User Study

We conducted the exploratory study over seven sessions with the aim to collect preliminary user perceptions and qualitative feedback about our interactive wallpapers concepts.

Fourteen (n = 14) participants (9 female) were recruited at the university campus from students and administrative employees. They participated in the study by pair into a laboratory environment for service and design interaction. Two back-projected walls were used to display the wallpaper concepts, complemented with furniture (tables, chairs) and tangible artifacts (keyboards, tablets, books and a sanitizer dispenser) to improve the simulation (Fig. 2).

For each session, the participants first gave their consents and were introduced to real electrochromic displays as examples. Then, participants were invited to engage with a think-aloud protocol for each simulated concept presented in a specific coherent order (similar to this paper) to follow an imaginary short story. The narrative was such that they just arrived at work and had to

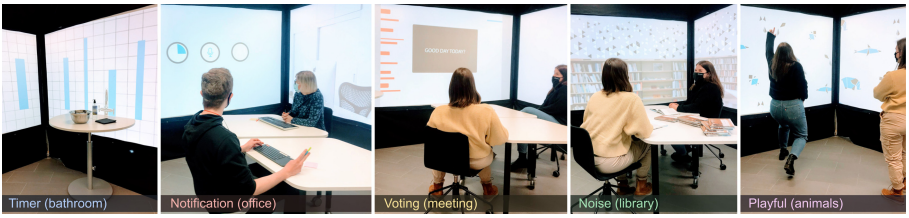

Fig. 2. User study setting for each wallpaper concept.

clean their hands in the bathroom with the *timer* concept. Then, they sat in an office with the *notification* concept and transitioned to a meeting room with the *voting* concept. Finally they stopped by the library with the *noise* concept (including simulated audio) before going home and engaging with the *playful* concept.

One instructor gave initial explanations of each concept while taking notes and another was changing the physical structure of the settings accordingly with the desired context. The *Wizard of Oz* method was used to simulate interactions, such as activity (e.g., washing hands) or touch detection.

Hassenzahl has defined user experience (UX) as "*a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service*" [2]. Thus, before leaving, participants had to complete a questionnaire to assess their feeling (1–5 scale) toward each wallpaper concept, and to collect their least and most preferred (including explanations) as well as additional open comments. Each session was video-recorded for subsequent analysis and lasted around 45 min in total.

3 Findings

Participants' quantitative ratings are reported in Fig. 3. Two concepts were clearly favored: *Noise (library)* and *Playful (animals)*. Interestingly, these results

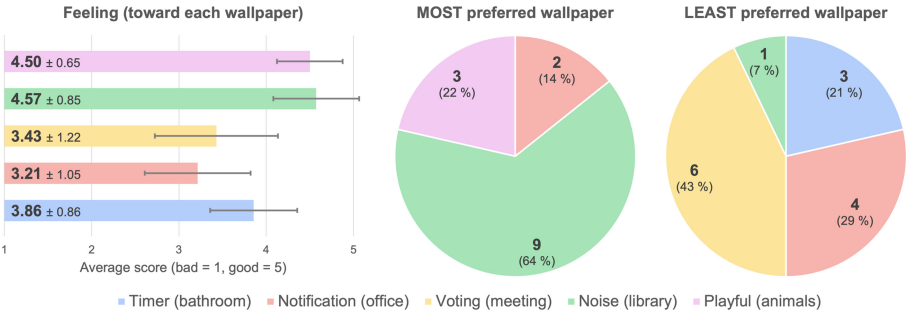

Fig. 3. Average score (including 95% confidence interval) of the participants' feelings toward each wallpaper as well as counts of the most and least preferred wallpapers.

also show a preference to adopt a repeating pattern design, which is more aligned with the mental representation of traditional wallpapers.

Timer. The low perceivability (n = 8) was the major drawback of this concept, either by taking time to notice the moving bars, or by considering them unclear. On the other hand, participants would like to exploit the *timer* concept with kids (n = 6) and in different contexts such as tooth-brushing (n = 4).

Notification. The lack of noticeability (n = 4) and usefulness (n = 4) were the main issues. Participants were also concerned to define the right placement (n = 8) and its visibility to others (n = 6), either to inform or to keep privacy.

Voting. The lack of usefulness (n = 5) was also the main issue with participants evoking the use of other technologies for the same context (n = 3).

Noise. This concept received a large amount of exclamatory positivity with participants evoking great usefulness and fit to its environment (n = 12), "*rather than looking like something hung on the wall*" (P2). However, some were also concerned about the noticeability (n = 8) and the inclination toward an opposite effect, considering it as a game for loudness (n = 8).

Playful. Even with a visually discreet interactive wallpaper, this concept received the same overall positive feedback as previous work [3] with participants also highlighting benefits for teaching (n = 6), physical exercise (n = 4) and memory activities (n = 4).

4 Future Work

Following our first findings, we considered a repeating pattern design (giving a flat or depth illusion effect). A prototype was made (Fig. 4) for the noise concept based on 3 flexible layers, blending solar panels, electrochromic displays and the circuitry to connect all of them. Other implementation approaches remain to be explored (such as multiple 2-layered standalone electrochromics) and studied over a series of experiments, measuring for instance their noticeability.

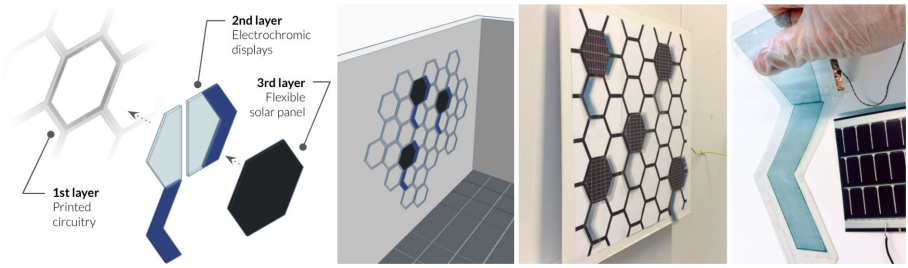

Fig. 4. Early interactive wallpaper conceptual implementation and real prototype.

Acknowledgements. This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 760973.

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